CHAPTER 9

PLANET EARTH: SYSTEMS AND PROCESSES

In this chapter, you will learn about Planet Earth — its structure and processes, including the interior of Earth, its crust, oceans and atmosphere.

MAJOR IDEAS

A. Energy from nuclear radiation and Earth's origins heats the interior of Earth.

B. The movement of tectonic plates shapes Earth's surface, creating mountains, rift valleys, seafloor spreading, earthquakes, volcanoes and tsunamis.

C. Oceans cover most of Earth's surface and help transfer energy through their currents.

D. Water is recycled through evaporation, precipitation and run-off from rivers and groundwater back into the ocean.

E. The atmosphere creates distinct weather patterns and climates at different geographic locations.

THE EARTH'S INTERIOR

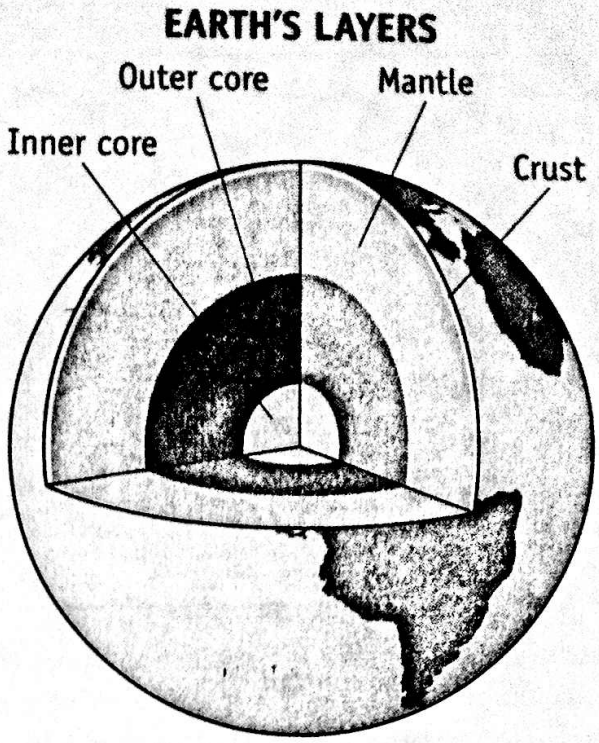
By comparing data from **seismic waves** (*waves created by earthquakes*), scientists studying earthquakes and volcanoes have concluded that Earth consists of a series of three distinct layers: **crust**, **mantle** and **core**.

CRUST

The crust forms a thick skin around Earth, much like the crust on a loaf of bread. All life takes place on this topmost layer of Earth. Earth's crust is made of solid rock. **Oceanic crust** is the floor below the oceans. About 5 to 8 km (*kilometers*) thick, it is made of heavy, dense rock. **Continental crust**, in land areas, is much thicker (*on average between 30 and 50 km deep*) than oceanic crust, but it is made of lighter, less dense rock. Continental crust is thickest below high mountains.

MANTLE

Below the crust is an area of hot, dense rock known as the **mantle.** Almost 3,000 km thick, the mantle makes up most of Earth's volume. The top of the mantle is solid, like the crust. As one goes deeper into Earth, both temperature and pressure rise. About 100 km below Earth's surface, the rock is near the melting point and becomes semi-solid or plastic.



CORE

The center of Earth is known as the **core.** It consists of an inner core of metal, mainly iron and nickel. Earth's core is extremely hot, with temperatures reaching well above 5,000°C. Radiation from radioactive substances and heat energy from Earth's formation create this heat (*geothermal energy*). The outer core is liquid. On the surface of Earth, the metals of the core would boil at these high temperatures, but pressure keeps the outer core in a liquid state. The inner core is made up mainly of iron. Although it is even hotter than the outer core, the tremendous pressure makes the inner core solid. The movement of Earth's metallic core is the source of Earth's magnetic field.

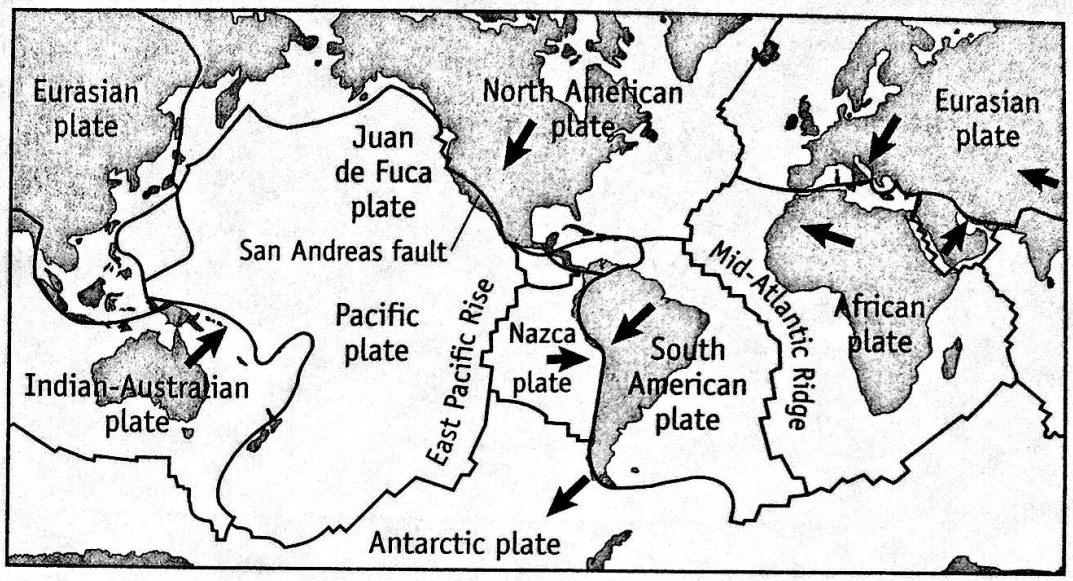
THE LITHOSPHERE: PLATE TECTONICS

In the early 20th century, **Alfred Wegener**, a German scientist, noticed the different continents of Earth seemed to fit together like a giant puzzle. For example, the eastern bulge of South America seemed to fill the space below West Africa. Coal seams and sedimentary rock formations on one continent matched those on another. Mountain ranges that ended at one coastline seemed to begin again on another coastline.

Wegener hypothesized that all continents of the world once fit together into a single, giant continent. Gradually, it separated and its pieces drifted apart. Wegener called this process "**continental drift.**" He found further evidence for his theory from the fact that the same fossils were often found in distant places, like West Africa and South America. Fossil remains on both sides of the South Atlantic were from animals known not to be great swimmers.

Many scientists at first rejected Wegener's ideas because he was unable to explain what forces could be powerful enough to move continents. Later evidence indicated Wegener was right. Scientists have found mountain ranges in the Atlantic Ocean and deep trenches in the Pacific Ocean that confirm his theory.

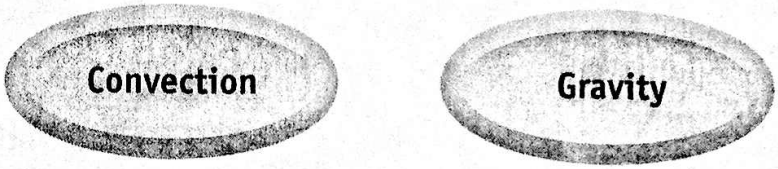
PLATE TECTONIC THEORY



Today, scientists refer to these ideas as the **"plate tectonic" theory**. They identify Earth's crust and part of the solid upper mantle as the **lithosphere**. About 100 km (*60 miles*) thick, the lithosphere is divided into several large slabs of solid rock known as **tectonic plates**. Earth's continents are attached to these plates, although the same plate often includes both oceanic and continental crust. Scientists believe that the tectonic plates act like solid chunks floating on top of the more plastic part of the mantle (***the asthenosphere***). The plates move at speeds of 1 to 16 cm each year. Over hundreds of millions of years, these plates can move thousands of kilometers.

WHAT CAUSES PLATE MOVEMENT?

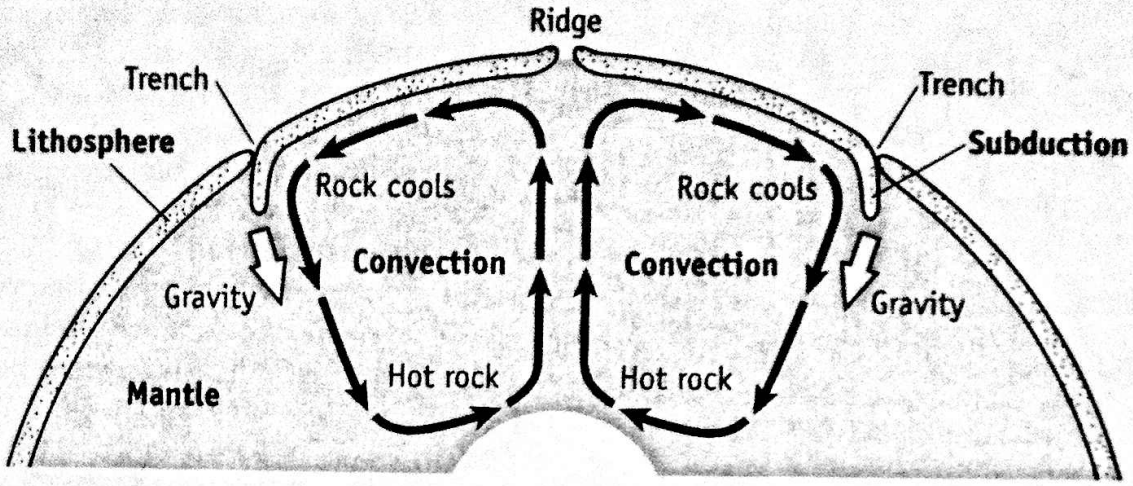
Scientists hypothesize that two forces may be responsible for the movement of the tectonic plates:



Convection is the spread of heat through the movement of a fluid substance. Inside the mantle, semi-solid rock is heated. As it is heated, it expands and becomes less dense. This lighter rock rises as gravity pulls down cooler, denser rock in its place. After the hotter rock rises and spreads, it begins to cool down. Once cooled, it sinks, creating a circular motion known as a convection current. Scientists believe it may be this **convection current** that pushes the plates above.

Gravity. You already know that the force of gravity is greater when an object's mass is greater. When oceanic and continental plates collide, the denser oceanic plate is pulled by gravity under the lighter continental plate. This process is known **subduction**. As the end of the oceanic plate sinks, it pulls on the rest of the plate as well.

DIAGRAM OF PLATE TECTONICS

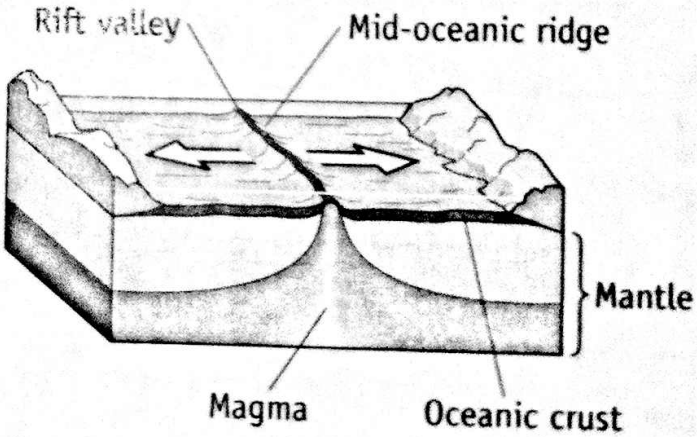


TYPES OF PLATE BOUNDARIES

Tectonic plates push and pull against each other like bumper cars in an amusement park. This results in a variety of different plate boundaries (*places where plates meet*).

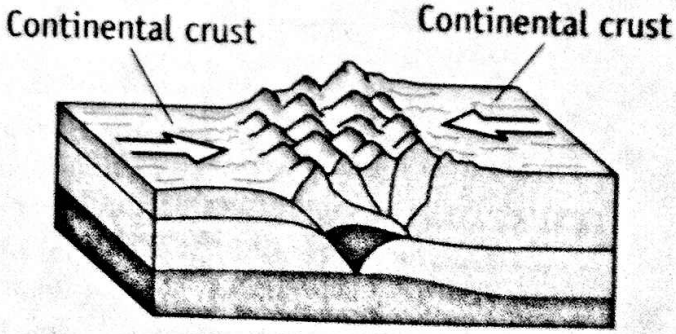
DIVERGENT PLATE BOUNDARIES.

Divergent plate boundaries occur where two plates are moving apart, leaving a gap. Hot molten rock, known as **magma**, fills the gap of the plates moving apart, creating a mountainous ridge. As the plates move further apart, a **rift valley** is created between two ridges. There is an important divergent plate boundary in the middle of the Atlantic Ocean, which is adding new crust to Earth's surface. This is known as the **Mid-Atlantic Ridge**.



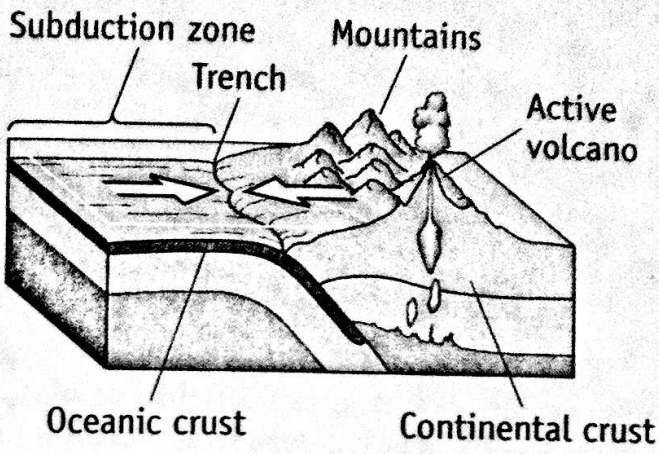
CONVERGENT PLATE BOUNDARIES

Convergent plate boundaries occur where two plates move together in slow collision. This leads to either folding or subduction. For example, the collision of the Indian tectonic plate with the Eurasian tectonic plate has led to the **folding** of Earth's crust and the creation of the Himalaya Mountains and Plateau of Tibet.



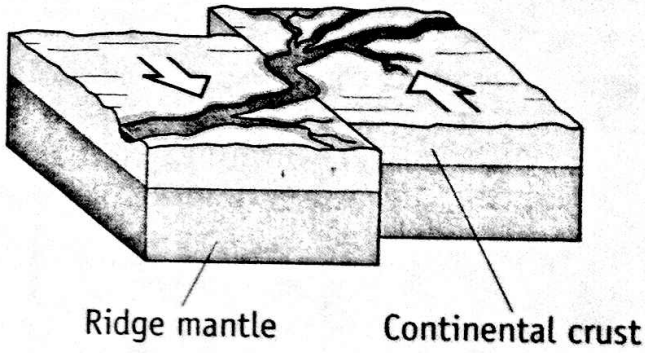
SUBDUCTION ZONE

A **subduction zone** is a type of convergent plate boundary that occurs where a dense oceanic plate collides with a lighter continental plate and into the mantle. Gravity pulls the heavier oceanic plate under the continental plate and into the mantle. This process is occurring around the borders of the Pacific Ocean. Subduction can also lift up the continental plate. For example, the oceanic plate slipping under the western side of South America has lifted up the continental plate, creating the Andes Mountains.



TRANSFORM PLATE BOUNDARIES

A **transform plate boundary** occurs where one tectonic plate slides by another plate horizontally. The San Andreas fault in California is an example of a transform plate boundary, where the Pacific plate slides past the North American plate.



APPLYING WHAT YOU HAVE LEARNED

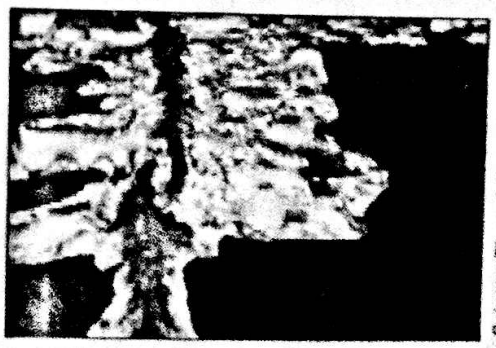
- Explain how gravity and convection currents lead to the slow movement of material within Earth.
- Make a table that identifies and describes the four types of plate boundaries.

EFFECTS OF TECTONIC PLATE MOVEMENT

The movements of tectonic plates explain many of Earth's surface features:

SEAFLOOR SPREADING

In the mid-Atlantic, measurements taken by scientists show that the separation of plates is actually causing the seafloor to spread. As the plates move apart, magma rises through the cracks of the sea floor creating a ridge of mountains. This creation of new crust would increase Earth's size, except that it is balanced by the destruction of crust through folding and subduction.



Science Photo Library

Topographic map of a part of the Mid-Atlantic Ridge

MAGNETIC STRIPING

When molten rock fills the gap between divergent plates, iron minerals in the rock line up with Earth's magnetic field. Earth's poles reverse themselves every several hundred thousand years — so that north becomes south. The alignment of iron minerals in the magma reverses itself, too. As a result, scientists have found alternating bands in which magnetic fields are reversed all along the Mid-Atlantic Ridge, providing additional evidence for tectonic plate theory.

FOLDING

When continental plates collide, they cause a folding of Earth's crust that creates new mountains. Such folding has led to the formation of the Himalaya Mountains and Plateau of Tibet — the highest landforms on Earth.

EARTHQUAKES

Plate movements can cause a break in Earth's crust, known as a **fault**. Plate movements can also cause vibrations known as **earthquakes**. As plates move, they create tremendous stress at plate boundaries. Eventually, parts of the rocky crust break, creating a fault and sending vibrations known as **seismic waves**. Scientists measure the waves sent by an earthquake with a **seismograph**. They can see that most waves originate at plate boundaries. The **Richter Scale** is used to measure the amount of energy released by an earthquake on a scale of 2 to 10. When an earthquake occurs under or near the ocean, it creates immense ocean waves of destructive force known as **tsunamis**. In December 2004, an earthquake in the Indian Ocean caused a devastating tsunami affecting South Asia and East Africa.

Science Photo Library

View of the San Andreas fault in Central California

VOLCANOES

In places where tectonic plates diverge or where one plate dives under another, pressure in Earth's mantle is reduced and some of the hot, solid rock turns to liquid. Any part of the tectonic plate that sinks into the mantle may also melt. Pockets of molten rock form beneath Earth's surface. This magma may break through weaknesses in Earth's crust. Magma, ashes and gases erupt and form a **volcano**. Once the magma reaches Earth's surface, it becomes known as **lava**. The location of most volcanoes and earthquakes has been shown to be almost identical with the location of plate boundaries. Often volcanoes appear on continental crust that is sitting over subducted oceanic crust. For example, the "Ring of Fire" around the Pacific Ocean — a zone of volcanoes and frequent earthquakes — coincides with the boundaries of the Pacific tectonic plate.

THE CYCLE OF ROCK FORMATION

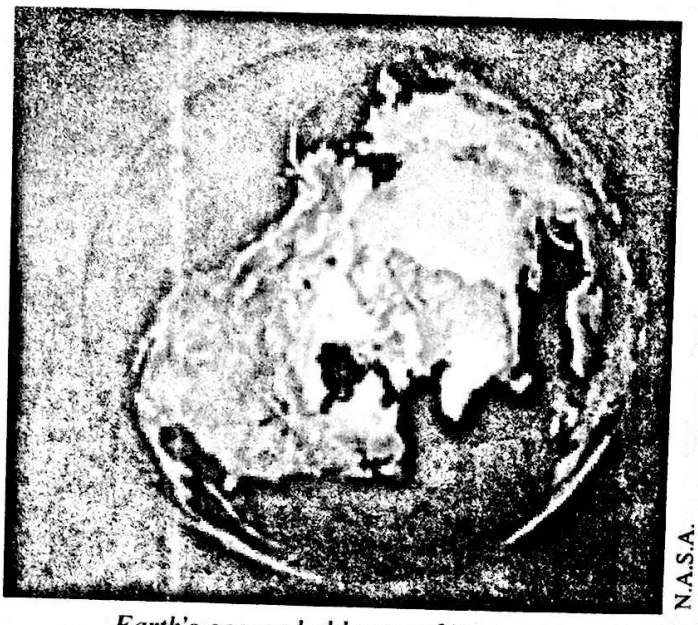
The rocks of Earth's crust go through cycles influenced by the movements of tectonic plates and other factors. Cooled magma forms **igneous rock**, such as granite or basalt. Erosion from water and air breaks down rocks on Earth's surface into pebbles, sand and dust. These fragments pile up and become compressed as **sedimentary rock**, like sandstone. Changes from tectonic plate movements may push sedimentary and igneous rocks below Earth's surface. Heat and pressure can change these rocks into **metamorphic rock**, such as marble or slate, or even melt the rock completely, so that it forms new igneous rock.

APPLYING WHAT YOU HAVE LEARNED

- Explain how the actions of tectonic plates have helped shape Earth's surface.
- Identify two types of evidence that support plate tectonic theory. For each type, explain how that evidence helps to support the existence of tectonic plates.

THE HYDROSPHERE: EARTH'S OCEANS

More than 70% of Earth's surface is covered by water. Scientists refer to this as the **hydrosphere**. About 97 percent of this water is in the oceans; the rest is either frozen in the polar ice caps or found in Earth's atmosphere, groundwater, and freshwater lakes and rivers.

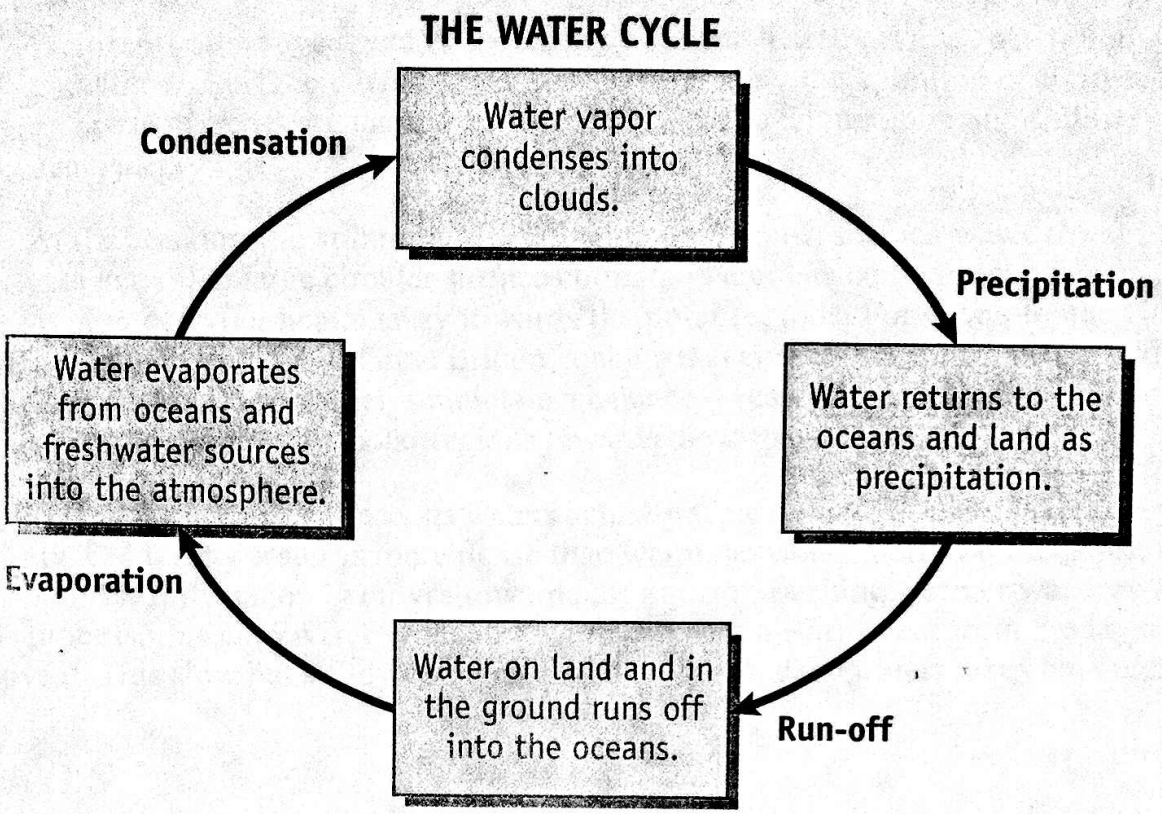


N.A.S.A.

Earth's oceans hold most of its water

THE WATER CYCLE

Just as Earth's lithosphere undergoes various processes, so does the hydrosphere. One of the most important is the water cycle. Solar energy heats the surface of the oceans, causing some of the surface water to evaporate into the atmosphere. Plants also create water vapor through **transpiration**. Water vapor rises until it becomes cooler, then condenses into tiny droplets small enough to float in the atmosphere as clouds. When the droplets grow heavier, they fall back to Earth's surface as **precipitation** — rain, snow or hail. Some precipitation returns to the ocean, but some falls on land where it is absorbed by the ground or forms lakes, streams and rivers. Some precipitation evaporates, but much of the groundwater and rivers eventually drain back into the oceans.

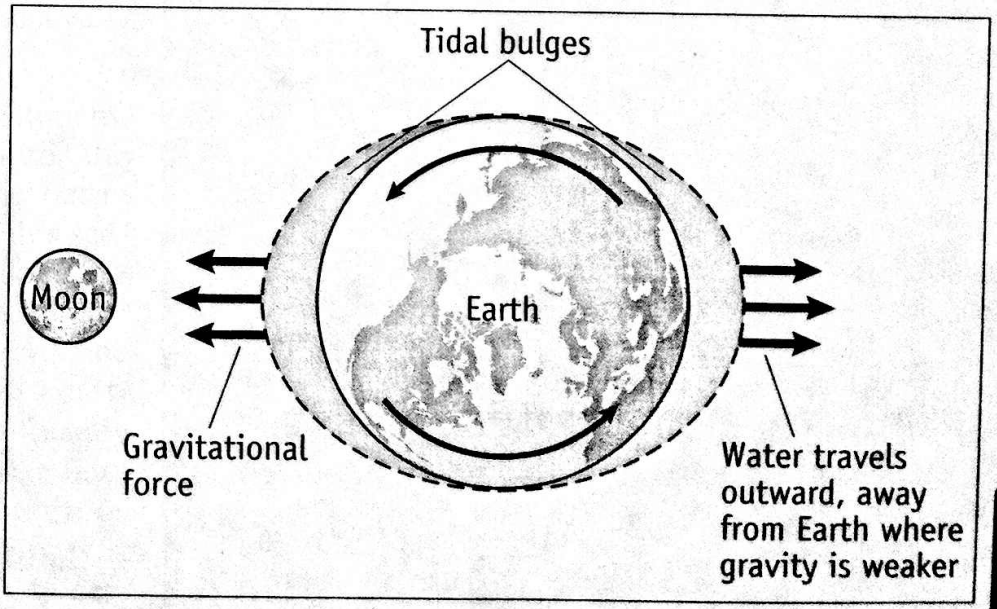


TIDES, CURRENTS AND WAVES

Earth's ocean waters are in constant motion. This can be seen in the tides, currents and waves.

TIDES

Each day, the surface level of the oceans rises up and falls down during ***high*** and ***low tide***. Tides are caused by the gravitational pull of the moon and sun on Earth's ocean waters. The ocean directly facing the moon bulges towards the moon, creating high tide, a time when sea levels are at their highest. On the opposite side of Earth is another high tide, caused by the force of Earth's spin where the moon's pull is weakest. Sea levels become highest when the moon and sun are both lined up on the same side of Earth, and lowest when they are on opposite sides. The tides are a remarkable demonstration of the effects of gravity.



CURRENTS

Ocean currents are movements of the ocean's waters. These currents occur both at the surface and below. Surface currents are mainly caused by the spinning of Earth, and winds. Deeper ocean currents are caused by differences in the temperature and **salinity** (*saltiness*) of ocean water.

At the equator, the spinning of Earth and winds push surface water towards the west. This sets in motion large circular surface currents. Water heated by the sun moves away from the equator, carrying heat energy towards the polar regions. For example, the Gulf Stream carries warm water towards Great Britain, making that country warmer than it would otherwise be. This transfer of energy helps maintain a balance — carrying heat from the tropics to colder regions, and cold from the polar regions towards the tropics.

Below the ocean's surface, its waters actually separate into different layers based on their density. Cold, salty water is more dense than warm, less salty water. At the poles, cold, salty water sinks. It then slowly moves towards the equator, pushing warmer water away. During this process, this cold water gradually warms up as it absorbs heat from the layers of water above it. This slow but steady circulation of the ocean's deep waters takes hundreds of years.

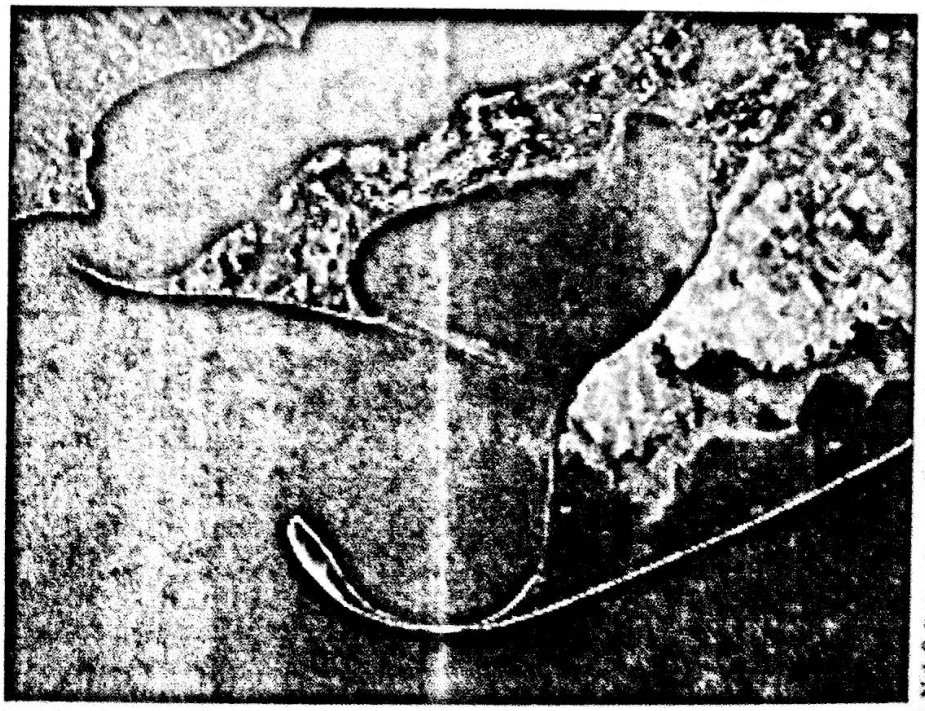
WAVES

Ocean waves appear to carry water, but in fact they only transfer energy. Water moves up and down on the ocean's surface in waves but does not actually move across with the wave. Winds, tides, and earthquakes all cause waves.

INTERACTION OF THE OCEANS AND LAND FORMS

The world's oceans interact with its land forms in a variety of ways.

Rivers carry sediment, including salts, into the ocean. Most of the ocean floor is covered by this sediment, which has taken millions of years to accumulate. Ocean currents carry some of this sediment to coastlines, where it forms sandy beaches. The actions of tides and waves can also erode shorelines, chipping away at rock and dissolving minerals.



NASA

Ocean currents help explain the reason for some landform shapes.

THE ATMOSPHERE AND CLIMATE

Around Earth is an envelope of gases known as the **atmosphere**, consisting mainly of nitrogen (78%) and oxygen (21%). The atmosphere absorbs solar radiation, moderates temperatures, and distributes water. The atmosphere consists of several layers, but the weather on Earth's surface (*precipitation, winds, and temperature*) is mainly determined by the **troposphere**, the layer closest to Earth. Different processes in the atmosphere lead to differences in **climate**, the average weather conditions occurring in a place over a long period of time.

WEATHER PATTERNS AND LOCATION

Weather patterns and climate are often the result of location or special geographic features. For example, temperatures are generally warmer the closer one gets to the equator. Temperatures become cooler at higher altitudes, such as on mountains or high plateaus. Because air is cooled as it rises above a mountain, the ocean side of a mountain often has heavy precipitation. The air loses moisture and becomes drier as it reaches the other side of the mountain, which may have very little rain or snow.

TORNADO ALLEYS

The spinning of Earth and the atmosphere's uneven heating create specific **wind** patterns. Cold sinking air creates areas of high pressure, while hot rising air creates areas of low pressure. Winds then blow from the high to low pressure areas. **Tornadoes** are high-speed winds that whirl in a funnel. They generally occur in the Great Plains of the Central United States. A tornado occurs when dry, cool air meets warm, humid air. Warm air at the center of tornadoes rises quickly, sucking in both air and objects.

TROPICAL HURRICANES

Hurricanes occur in tropical regions in late summer and early fall when the ocean water is very warm. The warm ocean water evaporates so quickly that it creates an area of low pressure. Air around the rising air column begins to spiral at high speeds. The hot air rises until it cools and condenses, releasing energy, causing heavy rains, winds and lightning.

National Oceanic and Atmospheric Adm.

A hurricane approaches landfall on the coast of Mexico

"LAKE EFFECT" SNOW

Water requires energy to change from a solid (*ice*) to a liquid, or from a liquid to gaseous water vapor. Its temperature therefore changes more slowly than land. Oceans and lakes are therefore cooler than neighboring land areas in summer and warmer than neighboring land areas in winter. One effect of this is "lake effect" snow. Areas near lakes often have heavy snow in winter. This is because large lakes are slow to freeze. As winds blow across the lake, they pick up water vapor. The water vapor condenses and becomes snow when the air passes over colder land areas. For example, winds blowing from west to east across the Great Lakes bring heavy snow to Buffalo, New York.

APPLYING WHAT YOU HAVE LEARNED

✧ The interaction of Earth's atmosphere and oceans results in several characteristic patterns on Earth's surface. Identify two ways in which the world's oceans and atmosphere interact and describe their effects.

CLIMATE AND BIOMES

The **biosphere** refers to all life on Earth. Weather patterns and climate influence what kinds of life forms can successfully live in a particular geographic location. Based on the interaction of climate, natural resources and life forms, scientists have identified several different **biomes**, or geographic regions with particular types of plant and animal life.

TEMPERATE DECIDUOUS FOREST

Temperate deciduous forests develop in mid-latitude regions where there is ample rain and moderate temperatures with cool winters. Trees change colors in fall and lose their leaves in winter. There is a wide range of plant and animal life.

TROPICAL RAIN FORESTS

Tropical rain forests develop in areas near the equator where there is ample rainfall and warm temperatures year-round. Large trees cover these areas with their leaves, forming a **canopy**. Despite the rapid growth of trees, the topsoil is actually very thin. Tropical rain forests are marked by a great abundance of animal and plant life, enjoying greater biological diversity (*known as biodiversity*) than any other biome.

GRASSLANDS

Grassland areas exist where the climate is drier and there is not enough rainfall to support large amounts of trees. Instead, grasses dominate, as well as large grazing animals, like cattle, antelope or bison.

DESERTS

Deserts are regions that receive less than 10 inches of rainfall annually. Deserts in the tropical latitudes, such as the Sahara Desert, have their own special forms of plant and animal life, which have adapted to the lack of water and extremes of temperature. Cacti, for example, store water in their stems.

TUNDRA

Tundra is found closer to the polar regions where the soil is so cold that trees cannot grow. Much of the ground is frozen part of the year. Tundras constitute a distinct biome, with their own plant and animal life, including grasses, small shrubs. Large mammals and birds migrate to these regions in the warmer spring and summer months.

N.A.S.A.

In a tundra, much of the ground is frozen.

WHAT YOU SHOULD KNOW

You should know that many processes occur in patterns in Earth's systems:

- **The Lithosphere.** The lithosphere is made up of the crust and solid upper mantle, and is broken up into tectonic plates. The movement of these plates moves and shapes Earth's surface. New crust is made when plates spread apart at divergent plate boundaries. Crust folds into new mountain chains where continental plates collide. Ocean crust folds under lighter continental crust at subduction zones. Earthquakes and volcanoes most often occur at plate boundaries.
- **The Hydrosphere.** The world's oceans cover over 70% of the planet's surface area. Currents, caused by winds and differences in water density, move the ocean's waters around the planet. Water is also moved between the atmosphere and land surfaces through the cycle of evaporation and condensation.
- **The Atmosphere.** The spinning of Earth, the unequal heating of air by the sun, the evaporation of water, and the effect of various landforms on the air result in weather — variations in temperature, wind, and precipitation. Climatic differences give rise to distinct ***biomes*** — geographic regions supporting different kinds of life, such as forests, grasslands, deserts and tundra.

CHAPTER STUDY CARDS

The Earth's Interior

- **Crust.** Outermost surface of Earth; oceanic crust is the floor beneath the oceans and is thinner and denser than continental crust. Continental crust in land areas is much thicker than oceanic crust.
- **Mantle.** Almost 3,000 km thick, the mantle is made up of hot, dense rock. As one moves deeper, the temperature and pressure rise.
- **Outer Core.** Molten nickel and iron.
- **Inner Core.** Solid, mainly iron.

Tectonic Plate Movements

- **Lithosphere.** Crust and top layer of mantle; divided into shifting tectonic plates.
- **Plate Boundaries**
  - **Divergent.** Two tectonic plates spread apart. Magma comes through the gap.
  - **Convergent.** Two tectonic plates come together.
  - **Subduction Zone.** Oceanic crust dives under lighter continental crust.
  - **Transform Plate Boundaries.** Two plates slide by horizontally.

Hydrosphere

- The hydrosphere is made up of all water on Earth's surface.
- 70% of Earth's surface is covered by oceans.
- The gravitational pull of the moon causes tides — cyclical rise and fall of the oceans.
- Ocean water is moved by surface and deep-sea currents.
- **The Water Cycle.** Water circulates through evaporation, condensation, precipitation, and run-off.

Atmosphere

- The atmosphere is an envelope of gases around Earth. It is mainly made up of nitrogen and oxygen.
- These gases absorb solar radiation, moderate temperatures and distribute water.
- The atmosphere creates distinct weather patterns. Heating of the atmosphere and Earth's spin create wind patterns. Surface features like mountains also affect weather.
- Variations in climate lead to different ***biomes*** such as temperate deciduous forests.

APPLYING WHAT YOU HAVE LEARNED

Make two cards on your own with the following topics:

- **Plate Tectonics: Causes and Effects**
- **Weather Patterns and Biomes**

CHECKING YOUR UNDERSTANDING

1 Scientists believe Earth's outer and inner cores are both composed of

A. liquid
B. solid
C. a high percentage of iron
D. the same pressure

- **Examine the Question**
- **Recall What You Know**
- **Apply What You Know**

This question requires you to recall information about Earth's structure and processes. You should recall that the outer core is made up of extremely hot liquid. The inner core, although even hotter than the outer core, is solid due to the extreme pressure. Knowing this information means that choices A, B, and D cannot be correct. Both the outer and inner core, however, are mainly composed of iron. Thus, choice C is the correct answer.

Now try answering some questions on your own about Earth's interior, lithosphere, hydrosphere, and the atmosphere.

2 The rising of hot, semi-solid rock in Earth's mantle and the sinking of cooler rock is known as

A. condensation.
B. radiation.
C. convection.
D. metamorphism.

ES: B 9–5

3 Which geologic events occur most often at a mid-oceanic ridge plate boundary?

A. magnetic pole reversals and cooling of ocean water
B. meteorite impacts and tilting of shorelines
C. hydrospheric pollution and adiabatic heating
D. volcanic eruptions and the creation of new crust

♦ Examine the Question
♦ Recall What You Know
♦ Apply What You Know

ES: E 9–6

4 Rocks are classified as igneous, sedimentary, or metamorphic based primarily on their

A. texture.
B. crystal or grain size.
C. method of formation.
D. mineral composition.

ES: E 9–6

5 When a continental crustal plate collides with an oceanic crustal plate, the continental crust is forced to move over the oceanic crust. What is the primary reason that the continental crust stays on top of the oceanic crust?

A. Continental crust is less dense.
B. Continental crust deforms less easily.
C. Continental crust melts at higher temperatures.
D. Continental crust contains more minerals.

ES: E 9–5

6 Which biome is correctly paired with its climatic zone?

A. moderate rainfall and temperatures — deciduous forest
B. heavy rainfall and warm temperatures — tundra
C. little rainfall and warm temperatures — tropical rainforest
D. moderate rainfall and cold temperatures — desert

ES: B 10–1

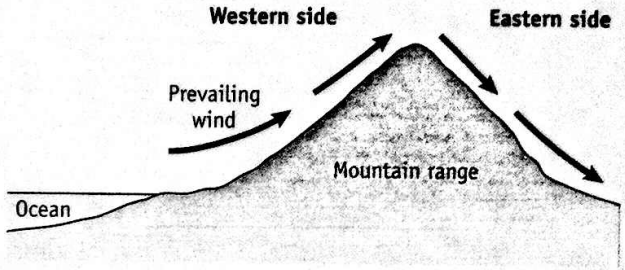
Use the information in the passage to answer the following question:

In the 1930s, most scientists believed that Earth's crust and interior were solid and motionless. A small group of scientists talked about "continental drift" — the idea that Earth's crust is not stationary, but is constantly shifting. From seismic data, geophysical evidence, and laboratory experiments, scientists now believe that lithospheric plates move at the surface. Both Earth's surface and interior are in motion. Solid rock in the mantle can be softened and shaped when subjected to the heat and pressure within Earth's interior over millions of years. Gravitational forces and convection processes are believed to be the driving force of plate tectonics. This theory cannot be directly observed and confirmed. The details of why and how plates move continues to challenge scientists.

7 In this passage, Earth's crust is described as "constantly moving." Give two examples of evidence that supports the conclusion that continents have drifted apart. (*2 points*)

ES: E 9–7

8 The cross section below shows the prevailing winds that cause different climates on the two sides of this mountain range.



Compared to the climate conditions on the western side of this mountain range, the conditions on the eastern side are more likely to receive

A. frequent hurricanes.
B. larger snow accumulations.
C. heavy rains.
D. less precipitation.

ES: B 10–2

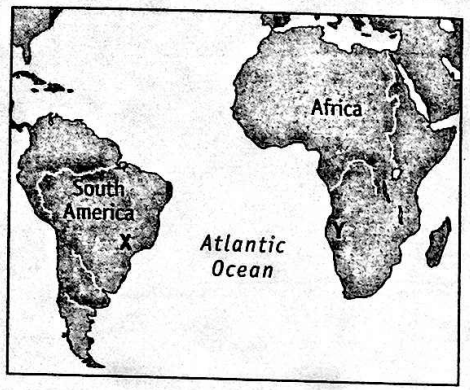
9 Clouds form in tropical hurricanes because the air is

A. sinking, expanding and then cooling.
B. sinking, compressing, and then warming.
C. rising, expanding, and then cooling.
D. rising, compressing, and then warming.

♦ Examine the Question
♦ Recall What You Know
♦ Apply What You Know

ES: B 10–2

The map to the right shows the present-day locations of South America and Africa. Remains of *Mesosaurus*, an extinct freshwater reptile, have been found in similarly aged bedrock formed from lake sediments at locations X and Y.



10 Which statement represents the most logical conclusion to draw from this evidence?

A. *Mesosaurus* migrated across the ocean from location X to location Y.

B. *Mesosaurus* came into existence on several widely separated continents at different times.

ES: E 9–7

C. The continents of South America and Africa were joined together when *Mesosaurus* lived.

D. The present climates at locations X and Y are similar.

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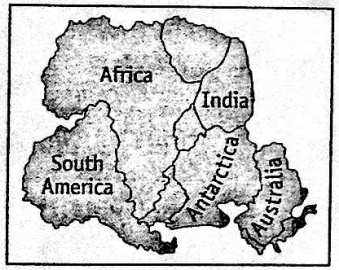
11 Approximately 100 km thick on average, the solid outer layer of Earth is divided into large slabs of solid rock known as tectonic plates. Over long periods of time, these tectonic plates separate, collide, or slide by each other. Identify two effects of plate tectonics. For each effect, explain how plate tectonics causes that effect. (*4 points*)

ES: E 9–6

Use the map below to answer the following question.



- Examine the Question
- Recall What You Know
- Apply What You Know

12 The diagram above illustrates the scientific theory stating that

A. millions of years ago Earth's land masses formed one giant continent.

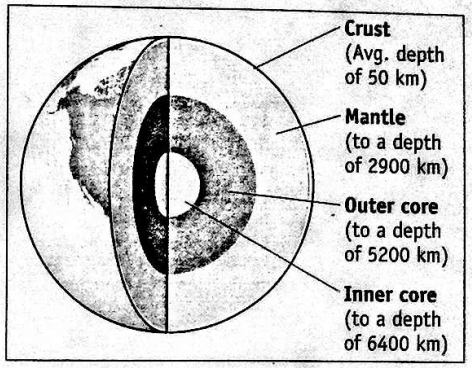
B. Earth's continents are slowly moving to become one giant continent.

C. Earth moves around the sun.

D. there is little difference in climatic patterns around the world.

ES: F 9–8

Use the information in the diagram below to answer questions 13 to 15.



13 The thinnest section of Earth's crust is found beneath Earth's

A. oceans.

B. mountain regions.

ES: B 9–5

C. desert regions.

D. coastal plains.

- Examine the Question
- Recall What You Know
- Apply What You Know

14 In which layer of Earth's interior do scientists believe the average temperature is approximately 5000°C?

A. crust

B. mantle

C. outer core

D. inner core

ES: B 9–5

15 Scientists have classified Earth's interior into the layers shown in the diagram based primarily on evidence gained from

A. drilling for oil.

B. studying volcanic eruptions.

C. measuring seismic activity.

D. measuring cyclone activity.

ES: B 9–5

16 Which of the following graphs accurately represents the relationship between the depth below Earth's surface and density?

ES: B 9–5